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(54) **Field device management system**

(57) The invention relates to field management in industrial process systems and similar systems. In the invention, maintenance management systems of industrial processes of separate plants located geographically apart from each other are networked in such a way that they may communicate with each other and exchange information on maintenance parameters of field devices of different types. As a result, experience obtained in

one industrial process can be transferred to other respective industrial processes and applications. By utilizing this globally collected cumulative information, it is possible to improve and specify the diagnostics of the separate local maintenance systems (6) essentially faster than in case if the local maintenance management system were independent and the diagnostics were changed on the basis of local experience only.

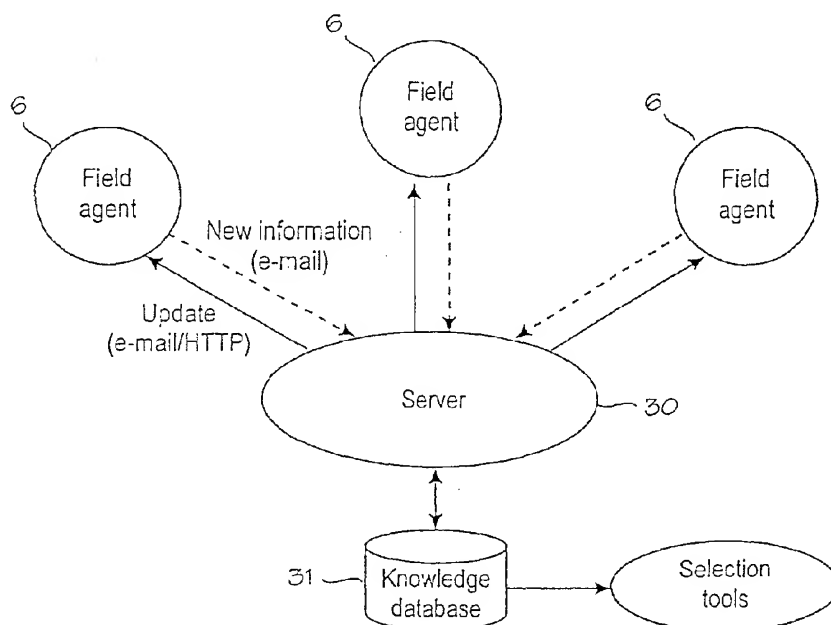


Fig. 3

Description

BACKGROUND OF THE INVENTION

[0001] The invention relates to field device management in industrial process systems and similar systems.

FIELD OF THE INVENTION

[0002] Field devices for industrial processes generally signify regulating devices, control devices, sensors, transducers, and the like, directly connected to the process. A typical field device is a control valve provided with a valve controller, such as the valve controller ND800 of Neles Controls Oy. So-called intelligent field devices are provided with a control logic or software, which makes it possible to control the field device locally for instance by means of a suitable control algorithm, to collect status and measurement data and/or to communicate with a field management system in accordance with a field communication protocol, such as HART (Highway Addressable Remote Transducer). In addition, intelligent field devices contain that much diagnostics at present that a field device is capable of informing of its failure. This information can be utilized for recognizing the device requiring maintenance, which reduces the maintenance costs because unnecessary device testings are avoided. More-over, the utilization ratio of a plant (factory) increases when unanticipated shutdowns decrease.

[0003] Typical field management systems are PC programs provided with graphical user interfaces and comprising properties as follows: configuration of field device, configuration database, maintenance control of field device on the basis of status data received from field device, and status database of field device. Examples of commercial field management systems are: Field Manager manufactured by Fisher-Rosemount Inc.; Documint manufactured by Honeywell Inc.; Cornerstone manufactured by Applied Technologies Inc.; Smartvision manufactured by Elsag-Bailey.

[0004] The maintenance control function is typically automatic and can be configured by the user. At maintenance control, a software scans the field devices as desired by the user and stores the status data desired by the user in the status database together with a time stamp. The status database can be browsed by means of a graphical user interface, which may be located anywhere in the plant. In this way, universal status data, which are very limited as far as e.g. maintenance data are concerned, are received from the field device. Status data items typically describing the condition of the device are: in condition and out of condition. This is often not enough for predictive or preventive maintenance.

[0005] Plant operators use so-called control room applications when running the plant by actual process control automation systems. Because the operator monitors the process day by day, he could start a maintenance

step of a predetermined field device in time, if he were informed of the condition of said field device. A problem is to bring an information on a failure in a field device to the knowledge of the operator or maintenance person of the plant, because automation systems do not support digital field communication protocols, such as HART. A reason for this is that they are primarily regarded as configuration protocols of a field device or the communication protocol does not support a transmission of operating status data of the field device. The diagnostics of the field device is clearly an area belonging to the field device supplier and not to the supplier of the actual automation system. The present control room applications show only the data required for operating the process, and the operator has to check the status of the field devices relating to said process in a separate field management software. To use a separate field device management software in the control room is problematic for the operator, because there is no connection between the field devices displayed by the software and the process to be monitored. This leads to the fact that the operator primarily monitors the process and does not react to the condition of the field device until it causes interference with the process.

[0006] The significance of diagnostics in intelligent field devices will continue to increase in a field bus environment. It is then especially important that the field device management concept and also the outputs and reports provided by it are clear and simple enough for the users. The present methods are not simple and sophisticated enough for this purpose. It is to be assumed that the two-way communication of the field devices will provide a flood of information in maintenance control software and automation systems. Accordingly, they rather increase the amount of work than decrease it. On the other hand, in order to achieve a simple and easy-to-use concept of diagnostics, the tools already existing in the control rooms should be utilized as much as possible. User interfaces of new application programs are not desired in the control room, because they require further training and maintenance and increase the complexity of running and monitoring the process. Actually, a user-friendly diagnostic system should not be visible to the user as a software provided with a separate user interface at all.

BRIEF DESCRIPTION OF THE INVENTION

[0007] An object of the invention is a maintenance management of field devices, which is reliable, simple and easy to use for the user.

[0008] This is achieved by a system for the maintenance management of field devices in industrial processes, each of them comprising a local maintenance management system. The local maintenance management systems of said industrial processes being networked in order to exchange information relating to the maintenance of field devices for a network level learning

and utilization of the information, and at least one of the local maintenance management systems is arranged to modify maintenance management parameters independently based on both data collected locally and data received from other local maintenance management systems.

[0009] Another object of the invention is a maintenance management system supervising field devices in industrial processes. The maintenance management system is arranged to

communicate with maintenance management systems of industrial processes of other plants located geographically apart from each other, in order to transmit and receive information relating to the maintenance management of the field devices, adjust maintenance parameters of the field devices independently in a self-learning manner based on both data collected locally and data received from other maintenance management systems.

[0010] The basic idea of the invention is to network the maintenance management systems of industrial processes of separate plants located geographically apart from each other in such a way that they are capable of communicating with each other directly and/or via a centralized maintenance management unit and transmitting information on maintenance parameters of different field device types. Each local maintenance management system is provided with an independent analysis, self-learning and control capability and arranged to control local maintenance management parameters independently in a self-learning manner based on both data collected locally and on the information received from the other local maintenance management systems. In this way, the experience obtained from or observed in one industrial process can be transferred to other industrial processes and applications of similar plants as well. By utilizing this globally collected cumulative information, it is possible to improve and specify the diagnostics of the separate local maintenance management systems essentially faster than in case if a local maintenance management system were a stand-alone system and the diagnostics were changed on the basis of local experience only.

[0011] In an embodiment of the invention, the local systems communicate may also communicate with or through a centralized maintenance unit. A centralized unit (server) makes it easier to manage the information exchange as the addresses of the local systems can be stored at the central unit only instead of maintaining address list in each local system. Further, the information can be selectively forwarded to those local systems having similar field devices. Also the security functions can be improved as it is easier to verify the transmitting or receiving local system at the central unit. The centralized unit may also analyze collected data by different statistical and mathematical methods and produce con-

trol data, which are transmitted to all local systems in the network. This allows, a field device manufacturer may monitor all its field devices in different parts of the world and to use the cumulative statistical data for development of new products and for enhancing the operation of the existing ones, so as to obtain optimal performance and optimal maintenance intervals, for example. The communication is preferably based on existing general methods, such as electronic mail, DDE, HTML, short message, Internet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The invention will now be described in more detail by means of preferred embodiments, with reference to the attached drawings, in which

Figure 1 shows a local maintenance management system of field devices connected to a process automation system of a factory,

Figure 2 shows components of a field agent according to a preferred embodiment of the invention, and Figure 3 illustrates a network of local maintenance management systems, i.e. field agents, according to the invention, and

Figure 4A and 4B are graphical descriptors illustrating a variation in values of a performance index and a maintenance need index as a function of time.

DETAILED DESCRIPTION OF THE INVENTION

[0013] The present invention can be applied to all industrial processes or the like comprising intelligent field devices. Intelligent field devices signify here any device relating to a process or an automated system or a control thereof which shall be controlled and which is capable of producing information describing the condition of the device directly or indirectly, this information being known as condition data. A typical intelligent field device of this kind is a control valve provided with a valve controller.

[0014] Figure 1 shows a general block diagram of a process automation system and, joined thereto, a maintenance management system of field devices according to the invention. The automation system comprises control room programs and databases 11 as well as process control programs and an I/O part 12. The control and I/O part 12 is connected via buses in accordance with HART standard to intelligent field devices constituted by control valves 14, 15, 16 and valve controllers 14A, 15A, 16A. The valve controller may be for instance an ND 800 of Neles Controls Oy. HART (Highway Addressable Remote Transducer) is based on transmitting digital data together with a conventional 4 to 20 mA analog signal. HART enables a two-way communication, by means of which intelligent field devices can be controlled and data can be read from them. A HART protocol follows the reference model of a protocol stack by OSI (Open System

Interconnection), which model has been developed by International Organization for Standardization (ISO). In layers 7 (application layer), HART instructions are transmitted. A HART instruction set contains universal commands understood by all field devices and device-specific commands providing functions which are restricted to an individual device (device type). The HART protocol enables a point-to-point configuration, in which there is a separate bus (pair of wires) between each field device and a master unit, or a multidrop configuration, in which up to 15 field devices are connected to the same field bus (pair of wires). The HART protocol is described in greater detail for instance in the publication HART Field Communication Protol: An Introduction for Users and Manufacturers, HART Communication Foundation, 1995. The HART protocol has also become industrial standard. However, it is to be understood that the type or implementation of a field communication interface, i. e. the field bus and the protocol used by it, is not significant for the present invention.

[0015] The condition of field devices is monitored by means of a field device maintenance management system 10 according to the invention, which system collects data from the field devices. For this purpose, each field device 14, 15 and 16 is connected via a respective field bus to a conventional HART multiplexer 9, which again is connected via an RS-485 bus 8 to a PC 6. The operating system of PC 6 is Windows 95/98 or Windows NT, for instance. Moreover, a work station 6 is connected to a local area network LAN of the factory (over which network it may communicate with control room software, for example).

[0016] The work station 6 contains a maintenance management software for field devices. The purpose of the software is to collect data from the intelligent field devices 14 to 16. This data collecting is fully automatic and requires no staff. On the basis of the collected data, the condition of the device can be analyzed and a message informing of the condition can be sent to another system, such as to the other parts of the automation system of the factory, e.g. to the display of a control room application.

[0017] Figure 2 is a general block diagram illustrating components of the field device maintenance management system or software according to a preferred embodiment of the invention.

[0018] Device modules are independent program components using a field bus in a manner they desire. A device module preferably is specific for each device type (not device-specific). For instance, two different control valves or control valves of different manufacturers may represent different types of device. Two identical field devices having different uses or wanting to monitor different matters may also belong to different device types. Generally, field devices requiring mutually different applications (device agents) for collecting and analyzing data and for producing status data can be classified to different device types. A device module contains

all necessary data and instruction sets for reading, analyzing and/or processing the status and diagnostic data of field devices of a predetermined type and also for producing status data for the device. Moreover, the device module 22 may store collected raw data and condition data of the device derived from them in a device database 24 for a later use. A more accurate diagnosis of the field device may then be made on the basis of the raw data by device-specific software, as by Valve-Manager in the case of ND800 valve controller. The device modules 22 have a simple interface to a software core 25, over which the device module 22 may send data and an information on the status or condition of each field device to the core 25. It is also possible that an intelligent field device analyzes its condition itself, whereby the raw data received over the field bus already is processed to some extent. In this case, the device module 22 may process the data further, for instance on the basis of the data it has received from the process automation system, or transmit the data as such to the core 25.

[0019] The software core 25 comprises a timer and a management of device modules and field devices. The task of the timer is to give each device module 22 separately a permission to use the HART field bus. The priority level of the field devices can be changed, whereby a higher number of data retrieval accesses in a time unit may be given to a predetermined field device than to another field device. The number of the device-specific priority levels may be for instance four: no data are retrieved from the field device, data are retrieved from the field device normally, data are retrieved from the field device twice as often as normally and data are retrieved from the field device four times as often as normally. Additionally, the timer may give the device module 22 a permission to collect timed data from the field devices at suitable intervals, for instance once an hour, a day, a week, a month or a year, which data are not urgent, but useful for preventive maintenance, for instance.

[0020] For the maintenance management of the device agents, the core 25 contains data of the device modules 22 of the system. For the field management, the core 25 contains data of the field devices subjected to the management of each device module 22.

[0021] The core 25 forwards data and status data to an analyzing block 21 and to a status checking block 23 and may receive adaptation instructions from the analyzing block 21 for changing the priority level of a predetermined device, for instance.

[0022] The status checking block 23 preferably stores the status data, transmitted by the device modules 22 via the core 25, in a field device-specific database. In other words, the status data of each field device are stored separately in the block 23. When the status checking block 23 receives the status data of a predetermined field device from the device module, it compares this status data with the preceding status, which is stored in the respective field device database in the checking block 23. If the status has changed, i.e. a

change has occurred in the condition of the field device, the checking block 23 sends the changed status data forward over an open communication interface, whereby the change in the condition of the field device appears at the user interface of the control room application, for instance. Such a transmission principle is called exception-based, because only the changes in the field device status are informed forward. The checking block 23 transmits the status messages to one or more report modules 26, 27, 28.

[0023] The analyzing block 21 analyzes the condition of the field devices on the basis of the data received from the core and utilizing knowledge data stored in a database 29. In a preferred embodiment of the invention, the field devices to be managed are control valves, and the analyzing block 21 determines two indexes describing the operation and condition of a control valve on the basis of the collected data: control performance index and maintenance need index.

[0024] The control performance index is a key when estimating the operation of a control valve from the viewpoint of the whole industrial process. It is used for trying to estimate the effect of the valve on process variability. The control performance index may also contain application-based data, e.g. whether the process is fast or slow. In a fast process, it is for instance important that the control valve responds to a control signal rapidly. In a slow process, respectively, a small static control error of the control valve is significant.

[0025] The maintenance need index, in turn, informs of the need of maintenance of control valves. The need of maintenance may be caused either by mechanical factors, such as wear, or by poor control performance itself. A wider diagnostics of a control valve associated with the use of the maintenance need index tries to locate also the source causing the maintenance need of the control valve, i.e. the object of maintenance.

[0026] The analyzing block 21 determines the control performance index and the maintenance need index by utilizing an expert system, whose inputs are components affecting the indexes. These components are: data to be collected from the field devices and application-based and device-/device type-specific knowledge (expertise) received from the knowledge database 29. This knowledge consists in the knowledge the field agent itself has learned and collected and, according to the basic idea of the invention, in the experience collected by other field agents in other industrial processes and in the knowledge of the performance and maintenance need of the control valves.

[0027] The valve controller is capable of collecting a large amount of different data concerning the control performance of the valve. The majority of the collected data is of on-line type, naturally. The most important parameters affecting the control performance and collectable at present already are: static error, rate of change in static error, dynamic error, rate of change in dynamic error, opening accumulation, load and rate of change in

load. Correspondingly, examples of components affecting the maintenance need index are: control performance, odometer of valve, odometer of actuator, number of valve reversals, number of actuator reversals, valve seal leakage, valve emission, valve wall thickness, cavitation level, load and rate of change in load.

[0028] By drawing the control performance index and the maintenance need index graphically, it is possible to give the user a clear picture of the operation and condition of the valve. It is even possible to program the analyzing block 21 to predict how the indexes develop as a function of time. Figure 4A is an example of the development of the performance index as a function of time. P1 is the minimum acceptable level, i.e. the threshold level, below which an alarm and a maintenance step are caused. Figure 4B is an example of the development of the maintenance need index as a function of time. M1 is the maximum level of the maintenance need, i.e. the threshold level, above which an alarm and a maintenance step are caused.

[0029] The analyzing block 21 (as the whole field agent) is an independent component, which does not need outside impulses to operate. Upon commissioning, it monitors regularly, fully independently, the condition of all field devices, such as control valves, connected to the field bus. The analyzing block 21 and the whole field agent are also capable of being adapted to changing circumstances. An example of changing circumstances is a weakening performance of a predetermined control valve. A learning block 20 then changes the adaptation of an analyser in the knowledge database, the analyzing block 21 gives the core 25 a new control signal "adaptation", as a result of which the core 25 subjects said control valve to a closer monitoring, by raising its priority level, for instance, so that an alarm of a malfunction can be given in time.

[0030] The analyzing block 21 also gives analyzing results to report modules to be reported forward.

[0031] Though a field agent operates independently, as far as users are concerned, it maintains, however, connections according to the invention to other field agents directly and/or via a centralized unit, known as a field agent server 30, as shown in Figure 3. This is indicated in Figure 2 by a learning module 20. When the analyzing block 21 finds a new information (e.g. a sudden failure of a control valve of a predetermined type in certain circumstances) which could be of significance for the operation of the other field agents as well, it gives the information to the learning block 20. The learning block 20 sends the information by a suitable communication method, such as electronic mail, DDE, HTML, short message, Intranet, Internet, to the field agent server 30. For this purpose, the learning module 20 may use report modules 26 to 28. The field agent server 30 delivers (multicasts) the information by a suitable communication method, such as electronic mail, DDE, HTML, short message, Intranet, Internet, to the relevant ones of the field agents 6 or to the whole (e.g. world-wide)

network of field agents 6. Before forwarding the information, the field agent server preferably verifies that the message have been received from an authorized local system. This may be based on an encrypted electronic signature, for example. The field agent server may also analyze the information in order to find the relevant field agents which might use the specific information. The field agent server maintains at least a list addresses of the field agents, and preferably also configuration data of the local systems in order to enable the screening of the messages prior to forwarding them. The field agent server may also be provided with a knowledge database 31 for a centralized collection and analysis of the performance and maintenance data.

[0032] The learning block of each addressed field agent 6 receives the information and, preferably upon verifying that the message is from the field agent server 30 and thereby likely to contain reliable information, the field agent 6 transfers the information to the knowledge database 29 for independent analysis and learning. It will thus be automatically included in the data used by the analyzing block 21. If, for example, the analyzing block 21 detects an information on a weakening performance of a valve of a predetermined type in certain circumstances in the knowledge database 29, it may change the priority level of control valves of this type, i. e. the reading rate in the core 25. The information may also be a new threshold level P1 or M1, in which case the alarm limits of a field agent are controlled on the basis of information received from elsewhere. For remote control purposes, it may be possible for the field agent server 30 to send a specific instruction in consequence of which the field agent 6 changes its operation in a desired manner.

[0033] In the above example, the field agent server 30 controls the information and communication sent by the field agents 6. Alternatively, the field agents may communicate with each other directly. In the above example, when the analyzing block 21 finds a new information (e.g. a sudden failure of a control valve of a predetermined type in certain circumstances) which could be of significance for the operation of other field agents as well, it gives the information to the learning block 30. The learning block 20 locates the information in the knowledge database of the agent and transmits the information by a suitable communication method, such as electronic mail, DDE, HTML, short message, Intranet, Internet, to the whole (e.g. world-wide) network of the field agents 6. The learning block of each field agent 6 receives the information and transfers it to the knowledge database 29, as was described above. This approach, however, requires that the addresses of all field devices are stored at each field agent, which is rather difficult to manage in practice. Also security problems may arise, as the field agent should be able to verify that the received information is really coming from a reliable source.

[0034] With reference to Figure 2 again, a report mod-

ule is a program component whose task is to change a status message to a format understood by another system. The other system may be for instance a database, a control room of an automation system or a maintenance reporting system. Report modules 26 to 28 provide an open communication interface with the other system. Open communication interface signifies for instance that the communication method by which the data of the field devices are transferred to the other system is independent of the type of field device and the nature of field communication interface. A report module may be for instance an electronic mail program 27 sending the status data of the field device as an e-mail report to the other system. A report module may also be for instance a WWW (World Wide Web) server 26 creating an HTML report from the maintenance data of the field devices, which report is offered as a WWW page. The other system may then read the WWW page with a commercial browser via Intranet or Internet. A report module may also create an HTML report or another text-based report, which is sent to the other system. A report module may also store the created (for instance text-based) report in the database, from where it can be read. A report module may also be a DDE server 28 communicating with the control room or other systems over a local area network LAN, for instance. The report modules 26, 27 and 28 are preferably Windows programs, possibly commercial programs. Between the blocks 21 and 23 and the report modules 26 to 28, there is then preferably an interface according to the Distributed Component Object Model (DCOM), over which interface an event message informing of the condition of the field device can be transmitted to the report modules 26 to 28.

[0035] The blocks 21 and 23 transmit the data to be reported to a report module for instance as a text-based report or file, which the report module inserts for instance as the content of an e-mail message or a short message (e.g. GSM), which message it sends to a predetermined address or several addresses. Correspondingly, the report module may change the content of the HTML/WWW page on the basis of the received text-based data. Internet and Intranet are TCP/IP networks known per se, the most significant application of which is WWW, but which also offer other data communication services applicable to the purpose of the present invention. These are all well-known data transmission technologies, detailed information and commercial applications of them being available, for which reason it is not necessary to describe them here any further. On the whole, the basic idea of the open communication interface concept of the present invention is that any general data transmission technology supported by another system may be applied as an open interface.

[0036] It is obvious that, as the technique develops, the basic idea of the invention may be implemented in many different ways. Consequently, the invention and its embodiments are not restricted to the above examples, but they can vary within the scope of the claims.

Claims

1. A system for the maintenance management of field devices in industrial processes, each of said industrial processes comprising a local maintenance management system, characterized in that

the local maintenance management systems of said industrial processes being networked in order to exchange information relating to the maintenance of field devices for a network level learning and utilization of the information, at least one of the local maintenance management systems is arranged to modify maintenance management parameters independently based on both data collected locally and data received from other local maintenance management systems.

2. A system according to claim 1, characterized in that the local maintenance management system comprises

a knowledge database storing application-specific and/or device-specific and/or device-type-specific knowledge, analyzing means for analyzing the condition of the field devices based on a measurement data from the respective industrial process and a knowledge data from the knowledge database and, when necessary according to the analysis results, for changing the maintenance parameters in the local maintenance management system, and means for modifying the contents of the knowledge data base according to both a maintenance history data collected locally and maintenance history data received from other local maintenance management systems.

3. A system according to claim 1 or 2, characterized in that said maintenance parameters include data representing a control performance of the field devices and/or the need of maintenance of the field devices.

4. A system according to claim 1, 2 or 3, characterized in that said maintenance parameters include a maintenance alarm limit and/or a performance alarm limit for the field device.

5. A system according to claim 1, 2, 3 or 4, characterized in that said maintenance parameters include a maintenance priority level for the field device.

6. A system according to claim 1, 2, 3, 4 or 5, characterized in that said knowledge data include data representing a control performance history data of a

field device and/or a field device-type and/or a process control application.

7. A system according to claim 1, 2, 3, 4 or 5, characterized in that said knowledge data include data representing a maintenance need history data of a field device and/or a field device-type and/or a process control application.

8. A system according to any one of claims 1-7, characterized in that the field device is a valve and the parameter representing the performance comprises or is affected by one or more of the following factors: static error, rate of change in static error, dynamic error, rate of change in dynamic error, opening accumulation, load, rate of change in load.

9. A system according to any one of claims 1-8, characterized in that the field device is a valve and the parameter representing the need of maintenance comprises or is affected by one or more of the following factors: control performance, odometer of valve, odometer of actuator, number of valve reversals, number of actuator reversals, valve seal leakage, valve emission, valve wall thickness, cavitation level, load, rate of change in load.

10. A system according to any preceding claim, characterized in that the local maintenance management system is arranged to independently adapt the maintenance management to the changes the management system has detected in the properties of the field devices.

11. A system according to any preceding claim, wherein the communication is based on one or more of the following communication methods: electronic mail, Dynamic Data Exchange, Hyper Text Markup Language, short message, Internet, OLE.

12. A maintenance management system for managing field devices in an industrial process, characterized in that said maintenance management system is arranged to

communicate with maintenance management systems of industrial processes of other plants located geographically apart from each other, in order to transmit and receive information relating to the maintenance management of the field devices, adjust maintenance parameters of the field devices independently in a self-learning manner based on both data collected locally and data received from other maintenance management systems.

13. A system according to claim 12, characterized in

that the maintenance management system comprises

a knowledge database storing application-specific and/or device-specific and/or device-type-specific knowledge, 5
 analyzing means for analyzing the condition of the field devices based on a measurement data from the respective industrial process and a knowledge data from the knowledge database 10
 and, when necessary according to the analysis results, for changing the maintenance parameters in the maintenance management system, and
 means for modifying the contents of the knowledge data base according to both a maintenance history data collected locally and maintenance history data received from other maintenance management systems. 15

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14. A system according to claim 12 or 13, characterized in that said maintenance parameters include data representing a control performance of the field devices and/or the need of maintenance of the field devices. 25

15. A system according to claim 12, 13 or 14, characterized in that said maintenance parameters include a maintenance alarm limit and/or a performance alarm limit for the field device. 30

16. A system according to claim 12, 13, 14 or 15, characterized in that said maintenance parameters include a maintenance priority level for the field device. 35

17. A system according to claim 12, 13, 14, 15 or 16, characterized in that said knowledge data include data representing a control performance history data of a field device and/or a field device-type and/or a process control application. 40

18. A system according to claim 12, 13, 14, 15 or 16, characterized in that said knowledge data include data representing a maintenance need history data of a field device and/or a field device-type and/or a process control application. 45

19. A system according to one of claims 12-18, characterized in that the maintenance management system is arranged to independently adapt the maintenance management to the changes the management system has detected in the properties of the field devices. 50

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20. A system according to any one of claims 12-19, characterized in that the communication is based on one or more of the following communication

methods: electronic mail, Dynamic Data Exchange, Hyper Text Markup Language, short message, Internet.

Fig. 1

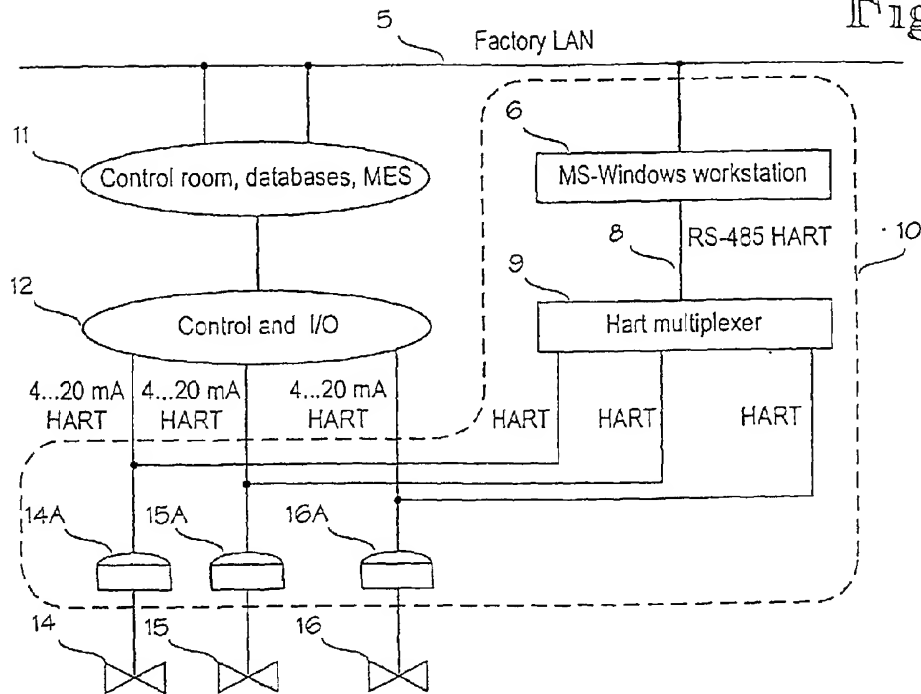


Fig. 2

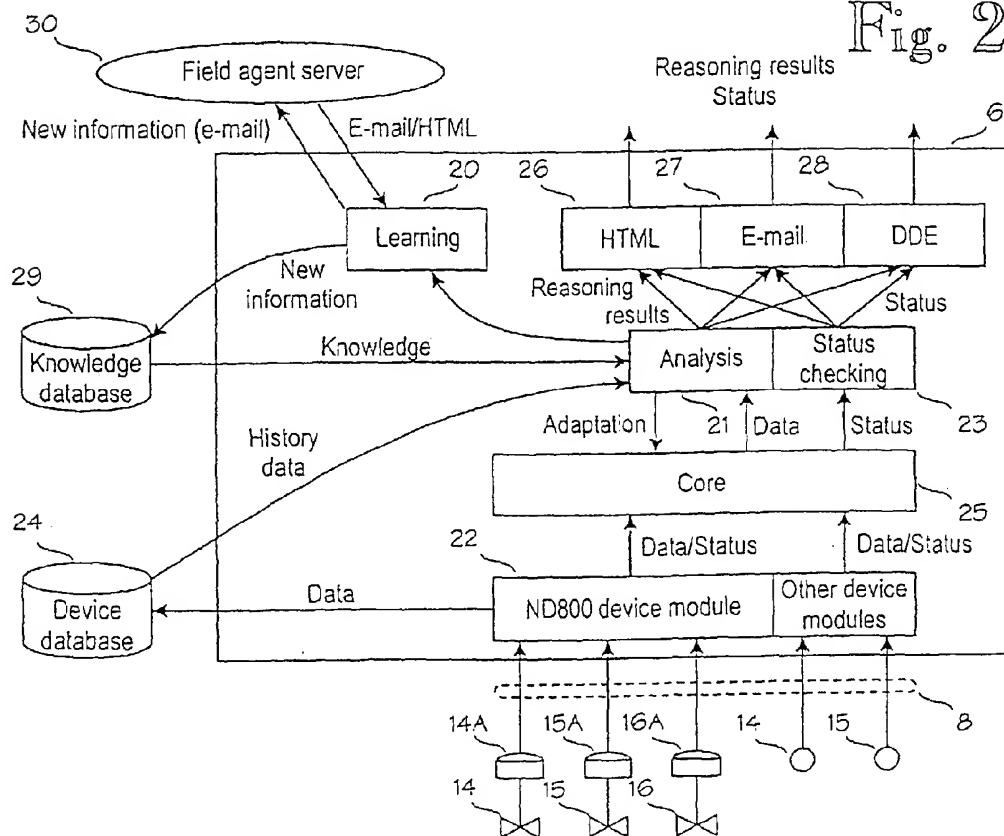


Fig. 3

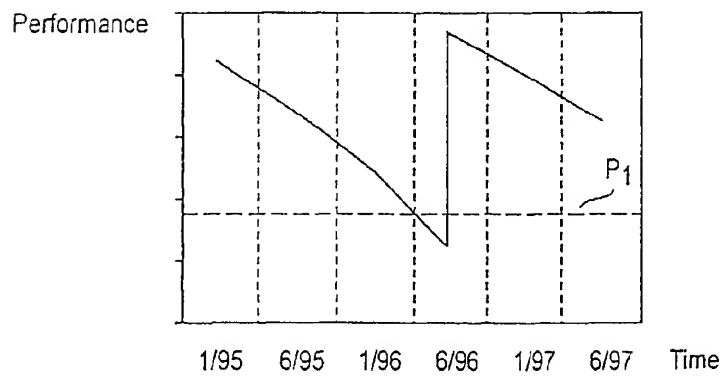
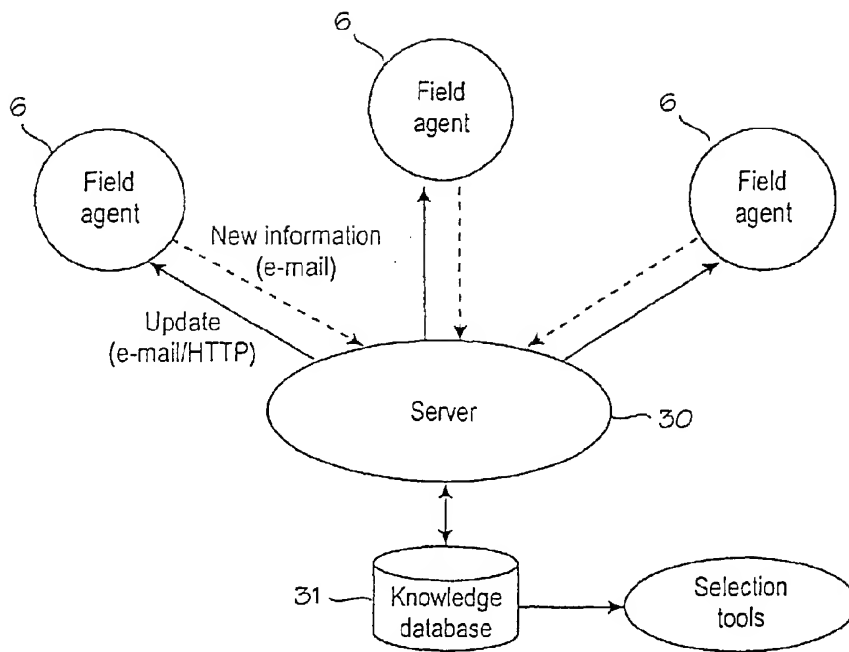


Fig. 4A

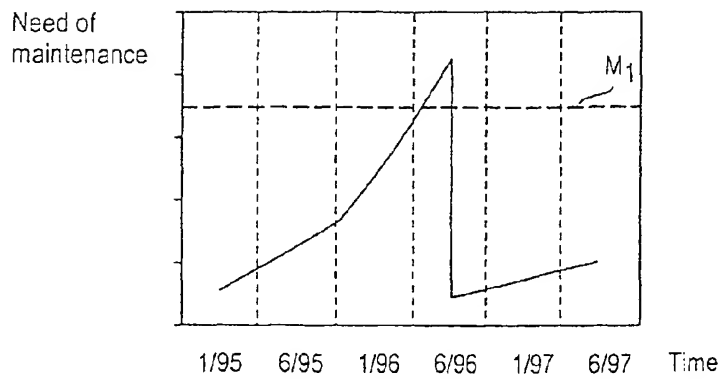


Fig. 4B



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 66 0108

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	WO 98 14848 A (FISHER CONTROLS INT) 9 April 1998 (1998-04-09)	1,12	G05B19/418
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